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Cherry Pollination Studies

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CONTENTS

CHERRY POLLINATION STUDIES

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INTRODUCTION

This bulletin reports four years' results of self- and cross-pollination tests with cherries at Wooster. The records of blooming seasons are presented, as the season is sometimes an important matter in cross-pollination of cherries.

It is exceptional for certain varieties, even tho they bloom profusely, to set fruit when self-pollinated. Others set a relatively low percentage of fruit when selfed, but not enough for a satisfactory crop. Still others set reasonably well with their own pollen, but there are some indications that the set of fruit can be increased by suitable cross-pollination. All varieties are not equally efficient as pollinizers for other varieties. The behavior of varieties as pollinizers has been studied.

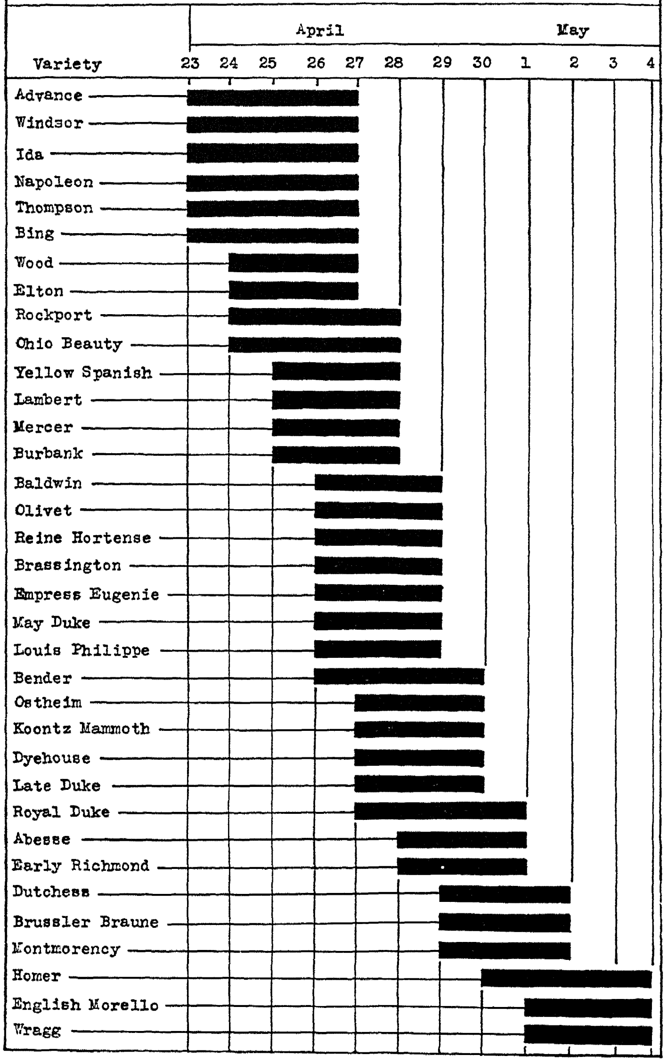
Reference is frequently made in the text to compatibility. Altho technical distinctions may be made, such terms as "self-incompatible", "self-unfruitful", and "self-sterile", have the same meaning from the practical viewpoint in this bulletin and are associated with inability to set fruit satisfactorily when self-pollinated. Some factors associated with incompatibility are discussed. In this respect, potency of pollen, pollen tube growth, embryo abortion, and chromosome behavior have been considered. Germination tests of pollen have been conducted in relation to the effectiveness of varieties as pollinizers.

SEASON OF BLOOM IN RELATION TO CROSS-POLLINATION

The season of bloom of cherry varieties is often of great importance from the pollination standpoint, particularly with varieties requiring cross-pollination. Cross-pollination under orchard conditions does not take place unless the varieties overlap in bloom. Seasons of bloom at Wooster, based on the average for the five years 1922-1926, are shown in Figure 1, taken from the Ohio Experiment Station Bimonthly Bulletin, May-June, 1927 (62)[1]. Table 1 groups the varieties in order of average blooming season.

[1]Numbers in parentheses refer to Literature cited, page 32.

FIG 1—CHERRIES, FIRST TO FULL BLOOM, 5-YEAR AVERAGE



In a normal year, sweet varieties with an early and Dukes with a medium blooming season will probably overlap sufficiently for cross-pollination; likewise, varieties classified as medium and late, and those as late and very late. Varieties with a late or very late blooming season are not satisfactory pollinizers for those with an early season. Varieties in adjacent groups may often fail to overlap in bloom; as, for instance, sweet varieties and sours such as Ostheim, Koontz Mammoth, and Dyehouse. Varieties two groups or more apart are likely to be unsuitable as pollinizers for one another. The season of bloom of sweet and most sour varieties in 1927, (Fig. 2), as in most years at Wooster, did not coincide.

TABLE 1.—Cherries Grouped in Order of Average Blooming Season at Wooster, 1922-1926

Early	Medium	Late	Very late
Sweet	**Duke**	**Duke**	**Sour**
Advance	Baldwin	Abesse	Homer
Windsor	Olivet	Dutchess	Wragg
Ida	Reine Hortense		English Morello
Napoleon	Brassington	**Sour**	
Thompson	Empress Eugenie	Early Richmond	
Bing	May Duke	Montmorency	
Wood	Louis Philippe	Brusseler Braune	
Elton	Bender		
Rockport	Late Duke		
Ohio Beauty	Royal Duke		
Yellow Spanish			
Lambert	**Sour**		
Schmidt	Ostheim		
Mercer	Koontz Mammoth		
Burbank	Dyehouse		

Fig. 2.—Showing difference in bloom of sweet and sour cherries at Wooster in 1927. The blossoms fell from the sweet cherries on the left, before the sour cherries on the right were in full bloom. It is obvious that cross-pollination between the sweet and sour cherries is not likely.

1—SELF- AND CROSS-COMPATIBILITY TESTS

METHODS AND MATERIAL

The work in 1924 and 1925 was conducted by W. F. Rofkar, and since then by the writer.

The trees were planted in 1912, 16 feet apart, and, consequently, now are crowded, but are producing good crops. Pruning has been rather severe, partly because of the close planting. The orchard is cultivated each year, and a cover crop sown in late summer. For the last two seasons the trees have received about three pounds of sulfate of ammonia apiece each year. Judging from the growth and color of the foliage, they are quite vigorous. Insects and diseases have been well controlled.

Attention was given to yield records in selecting the trees for the pollination work and an attempt made to use the ones likely to furnish the most fruit. Frosts during bloom in 1927 caused some injury to the flowers.

Unless otherwise noted, the data for a given variety were obtained from the same tree in any one year, but usually from different trees in different years. The flowers used were generally from ten to fifteen feet from the ground, where they could be worked conveniently from a stepladder. It was a matter of chance which flowers were hand-pollinated with the chosen varieties, but an effort was made to use only healthy flowers and to distribute pollen of a given variety to different sides of the tree. Twigs or spurs were selected of suitable length to accommodate the glassine bags, when these were used; the end two to three feet of branches were selected for the muslin bags. In 1927, before any fruit trees bloomed, a tree of Montmorency was enclosed for a self-pollination test in a cheesecloth frame tent in which a hive of bees was placed. Several methods of covering flowers to avoid undesirable cross-pollination are shown in Figure 3.

Sweet cherry flowers were not emasculated. Sour cherries and most Dukes were emasculated at the base of the corolla with a scalpel. Both emasculated and unemasculated flowers were covered with one-pound glassine bags or muslin bags before pollination. When pollinating, the bags were temporarily removed and only healthy looking flowers used.

Pollen was taken from the same tree as used for tests of fruit setting, and dried indoors on paper sheets. It was never more than 36 hours from the time the pollen was taken from the field until it was used for pollination. The pollen was placed in small capsules and applied directly by touching the inner surface against the stigma. Occasionally pollen was applied by finger.

Records were kept of the number of flowers pollinated, and the number of fruits setting. The sets referred to in the tables which follow were obtained after the so-called "June drop". Quite a number of hives of bees were located close to the orchard. There are about 50 varieties of cherries in the orchard.

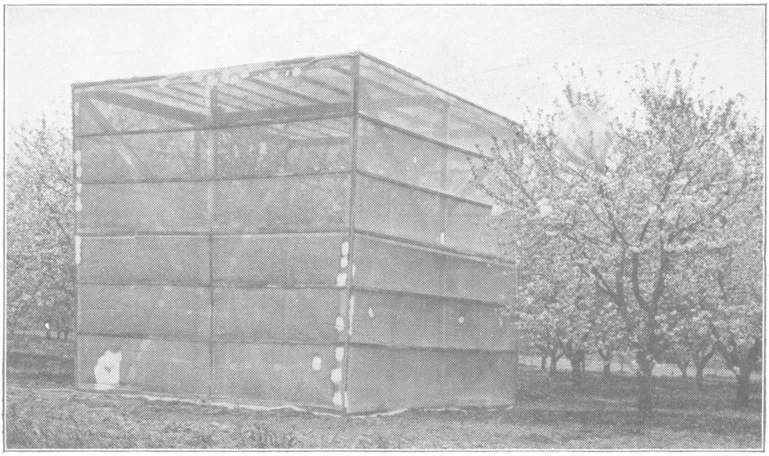


Fig. 3.—Several methods of controlling pollination. A Montmorency tree is shown enclosed for self-pollination in a cheesecloth frame tent in which a hive of bees is placed. Flowers covered with glassine and muslin bags for self- and cross-pollination tests are shown on the tree at the right.

For the most part, the number of flowers used in each test was not as large as could be desired. While the data, therefore, should not be regarded as an exact representation of the compatibility of varieties, they do seem to furnish information on the pollination requirements and on the suitability of various combinations of varieties.

SELF-COMPATIBILITY

Sweet varieties.—Studies at the Ohio Experiment Station as given in Table 2 agree with those cited (10, 11, 12, 13, 24, 25, 28, 30, 31, 32, 40, 52, 58, 59, 64, 66, 67, 72) and others, in showing that it is exceptional for fruit to develop from self-pollinated flowers of sweet cherry varieties.

The normal set of sweet cherries, determined after the June drop, ranged from 13 percent to 60 percent; the average for 11 varieties was 35 percent. It is evident from Table 2 that when cross-pollination was prevented, unsatisfactory sets on sweet varieties resulted.

TABLE 2.—Normal Set and Self-Compatibility of Sweet Varieties at Wooster as Tested by Bagging Flowers

Variety	Year	Normal set		Self-pollination	
		Flowers	Fruit set	Flowers	Fruit set
		No.	*Pct.*	*No.*	*Pct.*
Bing	1924	198	46	150	0
	1925	332	19	154	0
Elton	1926	108	32	117	0
Ida	1926	90	40	118	0
Lambert	1924	237	43	131	0
	1925	337	17	199	0
	1926	91	33	104	0
Napoleon	1924	204	54	125	0
	1925	234	16	186	0
	1926	144	41	76	0
Ohio Beauty	1926	129	50	117	0
Rockport	1924	208	17	144	.6
	1925	370	13	162	0
	1926	156	31	107	0
Schmidt	1924	197	60	139	2.1
	1925	300	28	573	0
Windsor	1924	141	48	117	0
	1926	105	38	109	0
Wood	1924	206	31	114	0
	1925	301	27	435	0
	1926	82	31	119	0
Yellow Spanish	1924	195	45	214	0
	1926	225	46	186	0

Sour varieties.—Sour cherries are generally supposed to be highly self-fruitful and to set good crops without cross-pollination. Chandler (4) stated that, in the season of 1914, Mr. E. D. Vosbury bagged flowers of most of the varieties of sour cherries grown at the New York Agricultural Experiment Station and found all setting well in bags. Hedrick and others (30) stated that there is no general complaint of poor crops thru self-sterility in New York; that from the behavior of perfectly isolated trees in all parts of the State, it would be premised that the sour cherry is most nearly self-fertile of all fruits. Roberts (54) showed that the two principal varieties grown, Montmorency and Early Richmond, are both highly self- and inter-fertile in Wisconsin, and that this would seem to eliminate any need of planting different varieties together as pollinizers. Miss Bradbury (3), in Wisconsin, found that fruit set in both Early Richmond and Montmorency whether the flowers were self- or cross-pollinated.

On the other hand, certain investigators believe that not every sour cherry is self-fruitful, and some workers seem to show that a variety which is self-fruitful in a given locality may be self-unfruitful under different environmental conditions. Crane (10), in England, found that sour cherries are not always self-fertile and some of them are self-sterile. In the Kentish Red[2] variety he reported one form or strain as self-fertile and another as self-sterile. In a later report, he gave the following relationships: **self-compatible,** Flemish Red 14.2 percent, Wye Morello 14.4 percent, Kentish Red "A" 22.7 percent, and Morello 28.3 percent set; **self-incompatible,** Kentish Red no set. Florin (25) believed that Ostheim is practically self-unfruitful. Investigations reported by Schuster (59), in Oregon, seemed to indicate that sour varieties may not be as highly self-fruitful as they are generally supposed to be; and he stated that sour cherries are self-sterile, self-fertile, or partially self-fertile, depending on the variety. Preliminary results presented in his publication seem to show that Montmorency, as far as tested by him, was self-unfruitful. The fact must not be overlooked, however, that presumably solid blocks and isolated trees of Montmorency have been productive.

The results of tests with Dyehouse, Early Richmond, Montmorency, and English Morello, given in Table 3, show that flowers bagged but not hand-pollinated set fruit. The percentage sets of fruit obtained, however, were lower with this method than the normal sets when flowers were exposed to cross-pollination or selfed by hand or worked by bees. Failure of pollen transfer, as suggested by the relatively low sets under bags when pollination is not assured, is comparable to a certain extent to the absence or inactivity of bees in the orchard.

In 1927, self-compatibility of Montmorency was tested by hand-pollinating flowers under glassine and muslin bags, and by covering a tree with a cheesecloth frame tent in which a hive of bees was placed. The hand-pollination assured transfer of pollen for the flowers under the bags, and the bees under the tent were active during bloom. It is possible that more pollen was applied by hand than would be transferred under normal conditions in the orchard, and that the bees confined in the tent visited the flowers oftener than is usual. On the other hand, abnormal conditions such as temperature and shading under the bags and tent may have

[2]Hedrick and others (30) refer to Kentish as a synonym of Early Richmond, and to Flemish as a synonym of Large Montmorency or Short Stem Montmorency. Crane (13) states that Kentish Red "A" is self-fertile, has short fruit stalks, and is confused with the Kentish Red, which has comparatively long stalks and is self-sterile.

exerted a detrimental effect on the setting of fruit. When means were taken to assure pollination, the percentage of selfed sets for Montmorency ranged from 26 to 31 percent. The normal set of the sour cherries tested during four years ranged from 21 to 42 percent; the average normal set was 33 percent. In 1927, a normal set of 46 percent was obtained for Montmorency, but this refers only to healthy flowers and does not include flowers injured by low temperature during bloom. Flowers of Montmorency killed by low temperature in 1927 were not included in the normal set so that results could be compared with self- and cross-pollinations where only healthy flowers were used.

TABLE 3.—Normal Set and Self-Pollination Tests with Sour Varieties

Variety	Year	Normal set		Self-pollination		
		Flowers	Fruit set	Treatment	Flowers	Fruit set
		No.	*Pct.*		*No.*	*Pct.*
Dyehouse	1924	240	33	Bagged, not hand pollinated	236	8.9
Early Richmond.	1924	123	36	Bagged, not hand pollinated	194	5.6
	1925	256	25	Bagged, not hand pollinated	214	3.3
	1926	274	21	Bagged, not hand pollinated	146	4.8
English Morello..	1925	388	22	Bagged, not hand pollinated	187	3.2
	1926	202	34	Bagged, not hand pollinated	147	9.5
Montmorency....	1924	117	35	Bagged, not hand pollinated	204	5.4
	1925	354	32	Bagged, not hand pollinated	187	5.9
	1926	200	42	Bagged, not hand pollinated	216	6.9
	1927	147	46	Tree under cheesecloth frame tent: hive of bees in tent. Data from a large limb	6235	31.0
				Branch covered with muslin bag:		
				Hand pollinated	310	26.0
				Not hand pollinated	345	11.0
				Flowers covered with glassine bag:		
				Hand pollinated	276	28.0
				Not hand pollinated	204	13.0

Duke varieties.—Sets of fruit obtained by various investigators are usually low when Dukes are self-pollinated. Gardner (28) selfed more than 1,000 flowers of May Duke and obtained about 1 percent set of fruit. Crane (10), using 860 flowers of May Duke, found that 13 fruits set, or 1.5 percent. Sutton (66) thought that May Duke was partly self-fertile. Oijin-Goethals (86) selfed 85 flowers of Abesse de Mouland and obtained no fruit. Florin (25) reported a set of 5.1 percent from selfing 628 flowers of Empress Eugenie. Schuster (59) found no fruit setting from 1,189 self-pollinated flowers of Baldwin. Sutton (66) said that Arch Duke is partly self-fertile. According to Crane (10, 12) May Duke, Royal Duke, Arch Duke, and Empress are partially self-compatible.

While the evidence in the literature on self-compatibility of Duke cherries agrees for the most part with the findings at Wooster, there is, however, a rather marked difference in percentage sets of fruit obtained for Late Duke. Tests at Wooster seem to indicate that Late Duke is practically self-unfruitful; Backhouse (2) and Sutton (66) pronounced it self-fruitful. Crane (10) reported 159 fruits, or a 10.3 percent set, from 1,542 self-pollinated flowers.

TABLE 4.—Normal Set and Self-Fruitfulness of Duke Varieties as Tested by Bagging Flowers

Variety	Year	Normal set		Self-pollination	
		Flowers	Fruit set	Flowers	Fruit
		No.	*Pct.*	*No.*	*Pct.*
Abesse	1924	202	18	207	0
	1925	291	14	318	0
Baldwin	1924	211	21	215	1.4
	1925	286	12	278	0
	1926	363	23	....	....
Bender	1924	209	18	129	0
	1925	245	12	328	0
Brassington	1924	206	26	190	2.1
	1925	354	14	562	.4
Dutchess	1924	208	53	200	5.5
	1925	281	23	313	5.8
Empress Eugenie	1924	197	18	145	0
	1925	317	17	353	.6
Late Duke	1924	210	21	188	.5
	1925	253	14	685	.1
	1926	98	26	....	....
Louis Philippe	1924	192	24	200	0
	1925	306	10	355	0
	1926	229	16	....	....
May Duke	1924	165	25	174	3.4
	1925	365	12	724	.1
	1926	263	32	....	....
Olivet	1924	205	19	218	.9
	1925	515	11	351	0
Reine Hortense	1924	200	38	178	0
	1925	336	16	213	.9
	1926	198	26	....	....
Royal Duke	1924	268	14	164	0
	1925	259	11	271	0

The normal set of Duke varieties at Wooster, as determined after the June drop, has ranged from 10 to 53 percent, the average for 12 varieties being 20 percent. As shown by the data in Table 4, it is exceptional for many Dukes to set fruit when selfed, and in no variety of this class has self-pollination given satisfactory sets.

CROSS-COMPATIBILITY

SWEET CHERRIES AS POLLINIZERS FOR SWEET VARIETIES

Sweet varieties for the most part are good pollinizers for one another, but certain combinations are ineffective.

Incompatible combinations.—Gardner (28) found that Bing, Lambert, and Napoleon, the three main sweet varieties grown in the Pacific Northwest, are not compatible with one another but are capable of pollinating other varieties. He showed that Black Republican, Black Tartarian, and Waterhouse seem to be the most efficient pollinizers for these three cross-incompatible varieties. Other good pollinizers of these mentioned by him are Elton, Wood, Coe, and Early Purple. Schuster (58, 59), Tufts and Philp (67), and others, agreed that Bing, Lambert, and Napoleon are inter-unfruitful, and they were of the opinion that Black Tartarian is a satisfactory pollinizer for these varieties. Crane (11, 12) gave three groups of incompatibles in sweet cherries, as follows: **Group 1**—Early Rivers, Bedford Prolific, Black Tartarian, Black Tartarian "A"[3], Knight's Early Black, Black Eagle; **Group 2**—Schrecken, Frogmore, Winkler, Waterloo; **Group 3**—Napoleon, Emperor Francis. Crosses made by him within these groups, with very rare exceptions, gave no fruit. Tufts and Philp (67) believed that Advance and Rockport, and Rockport and Early Purple, are inter-sterile.

As shown in Table 5, Bing, Lambert, and Napoleon are cross-incompatible at Wooster. Few nurserymen in the east list more than ten varieties of sweet cherries, and on the whole this is commendable. Since Bing, Lambert, and Napoleon, however, are varieties of the highest quality an unsuspecting grower might confine his choice to these varieties and have crop failures because of the cross-incompatibility between them. Substitution or mixtures in nursery stock might lead to the same result.

Compatible combinations.—Since all sweet varieties tested are self-incompatible, and since Bing, Lambert, and Napoleon are cross-incompatible, pollination by other varieties is essential for good crops, and the question arises as to which are the most suitable for this purpose. At Wooster, all sweet varieties overlap sufficiently in bloom for crosspollinizing purposes.

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[3]Crane (13) wrote as follows: "Regarding the identity of Black Tartarian there appears to be no general agreement. Under this name we have received three individuals; for reference they were designated 'A', 'B', and 'E'. Amongst other salient characters 'A' has small stellate flowers and long narrow leaves. 'B' and 'E' both have large and comparatively broad leaves, and large imbricate flowers. The fruits of 'E' are more conical and irregular in shape than those of 'B'. 'A' and 'B' are reciprocally incompatible and belong to Group 1. 'E', however, has proved to be compatible with varieties in this group.

Gardner (28) gave extensive tables showing the effect of pollen of sweet varieties on various other sweet varieties. Crane (10) obtained the following sets of fruit: Black Heart x Elton, 10 percent; Black Tartarian x Napoleon, 16.2 percent; Black Tartarian x Elton, 22.5 percent; Elton x Black Heart, 16.3 and 37.3 percent; Wood x Napoleon, 41.4 percent; and Wood x Black Tartarian, 32.9 percent. Tufts and Philp (67) recommended Chapman, Advance, Bing, Pontiac, and Early Purple, in the order named, as pollinizers for Black Tartarian.

TABLE 5.—Sweet Cherries as Pollinizers

		Year	Flowers	Fruit set
For sweet varieties			*No.*	*Pct.*
Bing	x Black Tartarian*	1926	104	22.5
	x Lambert	1926	176	0
	x Napoleon	1926	197	0
	x Schmidt	1926	192	9.8
	x Wood	1926	183	20.6
	x Yellow Spanish	1926	196	20.1
Lambert	x Bing	1926	108	0
	x Black Tartarian*	1926	100	19.0
	x Napoleon	1926	151	0
	x Schmidt	1926	199	18.0
	x Windsor	1926	123	24.6
	x Wood	1926	186	19.3
	x Yellow Spanish	1925	292	36.0
Napoleon	x Bing	1926	184	0
	x Black Tartarian*	1926	113	25.1
	x Lambert	1926	179	0
	x Schmidt	1926	197	20.3
	x Windsor	1926	184	24.3
	x Wood	1926	175	19.0
	x Yellow Spanish	1926	172	26.7
Windsor	x Bing	1926	146	29.6
	x Black Tartarian*	1926	118	24.4
	x Lambert	1926	166	32.7
	x Napoleon	1926	172	26.6
Wood	x Black Tartarian*	1926	197	21.3
	x Lambert	1926	192	18.7
	x Napoleon	1926	102	13.9
	x Windsor	1926	198	34.5
Yellow Spanish	x Windsor	1926	154	30.8
For sour varieties				
Early Richmond	x Lambert	1924	119	13.4
	x Napoleon	1924	129	35.6
	x Wood	1924	105	14.2
	x Yellow Spanish	1924	105	8.5
Montmorency	x Lambert	1924	107	13.9
	x Napoleon	1924	105	12.4
	x Wood	1924	103	5.8
	x Yellow Spanish	1924	96	7.3
For Duke varieties				
Brassington	x Napoleon	1926	141	30.5
	x Windsor	1926	123	37.4
	x Wood	1926	126	23.9
May Duke	x Napoleon	1926	109	27.5
	x Windsor	1926	154	33.7
	x Wood	1926	134	25.3

*Pollen obtained from Prof H. B. Tukey, New York Agr. Exp. Sta.

Tukey (68) reported observations and experiments with Black Tartarian as a pollinizer for Windsor. He wrote that in an orchard in New York State the owner had noticed that the crop in a Windsor block 11 rows wide was less on the east side than on the west. Along the west side there was a row of Black Tartarian trees. Tukey found in the season of 1924 the normal blossom set in the first row of Windsor trees, adjacent to the Black Tartarian row, was 62 percent more than in the second row, and 127 percent more than in the third to eleventh rows, inclusive.

Wellington (72) gave a report of the effectiveness as pollinizers of Giant and Seneca, two new varieties originated at the New York Experiment Station. Giant is said to have proved to be a good pollinizer for Abundance, Lambert, Lyons, Napoleon, and Windsor, each of which will also pollinate the Giant. At Geneva, N. Y., Seneca produced pollen very profusely, and altho it refused to set fruit when selfed, it successfully pollinated Black Tartarian, Ida, Giant, Lyons, Napoleon, Republican, Schmidt, Windsor, and Yellow Spanish, and in no cross did it give any evidence of being incompatible.

Observations in Ohio nurseries have shown that Mazzard seedlings and the varieties budded on them are easily confused, and hence such seedlings may sometimes unknowingly be present in an order of standard sweet varieties. Schuster (59) was of the opinion that some Mazzard seedlings set a crop of fruit on certain sweet varieties while others fail entirely. It is conceivable that Mazzard seedlings might pollinate various sweet varieties successfully and on this account be of some benefit in an orchard, but the fruit of Mazzards is of inferior quality. No data on the compatibility of Mazzard seedlings and standard sweet varieties are available at Wooster.

Data showing the effect of pollen of certain sweet varieties on various other sweet varieties are given in Table 5. At Wooster, Windsor seems to be the best general pollinizer for the sweet varieties under test, altho the results may not be significantly higher than for Black Tartarian, Yellow Spanish, Wood, and other sweet varieties. Except for certain cross-incompatible combinations, sweet varieties in general are good pollinizers for other sweet varieties.

SWEET CHERRIES AS POLLINIZERS FOR SOUR VARIETIES

Since sweet cherries bloom earlier than sour cherries, the difference in seasons of bloom is of itself probably sufficient to preclude suitability of sweet cherries as pollinizers for sour varieties. The fact that there are a number of Dukes indicates that some cross-fertility is possible.

There is very little evidence available in the literature on the effect of sweet cherries as pollinizers for sour varieties. Roberts (54) pollinated Early Richmond and Montmorency by Wood and obtained sets of 10.3 and 5.7 percent, respectively. Crane (11) found that the self-unfruitful Kentish Red when pollinated by Wood gave a set of 5 percent. Both these crosses were below the percentage set expected for a good crop.

The data in Table 5 indicate that sweet cherries will fertilize sour varieties. However, there seems to be little practical advantage to be gained from the use of sweet cherries as pollinizers for sour varieties.

SWEET CHERRIES AS POLLINIZERS FOR DUKE VARIETIES

The percentage sets in Table 5 seem to show that the sweet cherries tested are suitable as pollinizers for Duke varieties, such as Brassington and May Duke. On the other hand, Gardner (28) found that May Duke pollinated by Lambert gave only 3 percent set, and 69 flowers of May Duke x Napoleon resulted in no fruit. Crane (10) obtained the following sets of fruit: Late Duke x Wood, 9.8 percent; May Duke x Napoleon, 8.1 percent; and May Duke x Black Eagle, 14.2 percent.

As shown in Table 5, pollen of Napoleon, Windsor, and Wood resulted in sets which were higher than the average of 20 percent, or normal. These sets are higher than those obtained from self-pollination of Duke varieties. The sweet cherries are apparently good pollinizers for the Duke varieties with which they overlap in bloom.

Sour Cherries as Pollinizers

SOUR CHERRIES AS POLLINIZERS FOR SOUR VARIETIES

Studies of cross-pollinations between sour varieties have been reported by a number of investigators. Roberts (54) obtained the following sets: Richmond x Montmorency, 28.2 percent; Richmond x Morello, 25.7 percent; and Montmorency x Morello, 12.9 percent. Crane (10) found that Kentish Red x Morello gave 10.2 percent, and Kentish Red "A" x Morello 28 percent. Johansson (34), in Sweden, stated that Stora Klärbar (Early Richmond?) has almost always given poorer results by selfing than by crossing. Florin (25) stated that the Ostheim x Morello cross gave good results, but as these two varieties do not usually blossom at the same time, the experiment has but little practical value. Schuster (59) gave the results of a number of crosses in Oregon most of which are considerably lower in percentage set of fruit than that obtained at Wooster.

As shown in Table 6, Dyehouse and English Morello set a fair percentage of fruit on Early Richmond and Montmorency, but as no increase in set over that of self-pollination was obtained there seems little to be gained from inter-planting them as pollinizers for Early Richmond or Montmorency.

Pollination of Montmorency by Early Richmond.—During the course of the pollination studies the question arose as to whether the percentage sets of Montmorency would be higher when that variety was cross-pollinated by some suitable variety than when self-pollinated.

Evidence available in the literature seems to indicate higher sets of fruit for Montmorency pollinated by Early Richmond than for Montmorency selfed. Roberts (54) showed that 480 selfed flowers of Montmorency gave 83 fruits, or 17.6 percent, whereas Montmorency x Early Richmond on pollination of 489 flowers resulted in 101 fruits, or a set of 20.7 percent. Miss Bradbury (3), in Wisconsin, found that self-pollination of Montmorency gave a lower percentage set than cross-pollination and she was of the opinion that further experiments are necessary to determine whether this difference is constant. Schuster (59) stated that the Early Richmond, commonly called the Kentish, is one of the varieties most commonly found inter-planted with the Montmorency. He mentioned that as this combination invariably gives a good crop, it works very well from the pollination standpoint, altho the Kentish is not as good a canning cherry as the Montmorency. Murneek[4] found that Montmorency sets very much better when open-pollinated, altho in some years apparently a fair crop may be secured when it is selfed. He is of the opinion that, while increasing the set on Montmorency, Early Richmond does not seem to be an ideal pollinizer, since much heavier setting is usually obtained under conditions of open-pollination.

Self-fruitfulness of Montmorency and the effectiveness of Early Richmond as a pollinizer for it, were tested by a number of methods in 1927. The results are given in Table 6.

Montmorency when self-pollinated in 1927 gave sets of 26 to 31 percent (Table 6). Such percentages, however, are lower than those obtained the same year when Montmorency flowers were exposed to the effect of pollen of the various varieties that overlap Montmorency in bloom at the Ohio Experiment Station. As shown

[4]Murneek, E. A., Department of Horticulture, University of Missouri, correspondence, Nov. 4, 1927.

in Table 6 cross-pollination of Montmorency by Early Richmond seems at times to result in a higher set than self-pollination.

There is no information to indicate the proportion of Early Richmond trees necessary in an orchard to increase appreciably the set of fruit on Montmorency. Since Early Richmond is not as highly esteemed as Montmorency, planting a sufficient number of the former to affect yield from cross-pollination might be undesirable. While it is possible that the results may be seasonal, or may be obtained under certain conditions and not under others, it seems worth while to note the trend of experimental evidence, which shows that Montmorency has given higher percentage sets of fruit when pollinated by Early Richmond than when selfed.

TABLE 6.—Sour Cherries as Pollinizers

		Year	Flowers	Fruit set
			No.	*Pct.*
For sour varieties				
Early Richmond	x English Morello	1926	95	15.8
Montmorency	x Dyehouse	1926	84	12.4
	x English Morello	1926	91	13.2
Pollination of Montmorency by Early Richmond				
Montmorency:	Normal set	1927*	147	46.0
Montmorency selfed:				
Tree under cheese cloth frame tent, hive of bees in tent. Data from a large limb		1927	6235	31.0
Branch covered with muslin bag hand pollinated		1927	310	26.0
Flowers covered with glassine bags, hand pollinated		1927	276	28.0
Montmorency x Early Richmond:				
Branch covered with muslin bags		1927	302	42.0
Flowers covered with glassine bags		1927	193	36.0
For sweet varieties				
Bing	x Early Richmond	1926	117	4.7
	x English Morello	1926	71	2.8
	x Montmorency	1926	107	6.5
Lambert	x Early Richmond	1924	76	5.2
	x English Morello	1926	90	3.3
	x Montmorency	1926	213	4.2
Napoleon	x Early Richmond	1926	182	4.4
	x English Morello	1926	100	3.0
	x Montmorency	1926	71	5.1
Schmidt	x Dyehouse	1926	103	3.9
Windsor	x Early Richmond	1926	86	4.6
	x English Morello	1926	98	4.1
	x Montmorency	1926	104	3.9
Wood	x Early Richmond	1926	118	5.1
	x English Morello	1926	90	5.6
	x Montmorency	1926	109	4.6
Yellow Spanish	x Early Richmond	1926	109	4.6
	x English Morello	1926	106	3.9
	x Montmorency	1926	114	5.3
For Duke varieties				
Brassington	x Early Richmond	1926	118	22.2
May Duke	x Early Richmond	1926	144	21.5

*The percentages set in 1927 do not include flowers injured by low temperature.

It must be borne in mind that Montmorency gives reasonably good crops when planted as isolated trees or solid blocks, but a number of growers have complained that yields have not always been as high as desired. Placing hives of bees in the Montmorency orchard, and more careful and judicious spraying, fertilizing, pruning, and other cultural practices probably would lead to greater production in many cases and give more marked results than would be obtained by inter-planting with Early Richmond.

SOUR CHERRIES AS POLLINIZERS FOR SWEET VARIETIES

There seems to be conflicting evidence in regard to the effect of sour cherries as pollinizers for sweet varieties. Schuster (59) stated that sour cherries will set fruit on the sweet cherry, but, in comparison with varieties of the sweet cherry, are poor pollinizers. He claimed that on the whole, while fruit will set by using sour cherries as pollinizers, their use for sweets cannot be recommended. On the other hand, Crane (11) obtained good sets but used a relatively small number of flowers.

As shown in Table 6, sour cherries gave a low set of fruit on sweet varieties. Sour cherries in the tests at Wooster were not good pollinizers for sweet varieties because the two species did not bloom simultaneously, and the percentage set of fruit was low.

SOUR CHERRIES AS POLLINIZERS FOR DUKE VARIETIES

Crane (10), using sours as pollinizers for Dukes, secured the following sets: Late Duke x Kentish Red, 22.9 percent; May Duke x Kentish Red, 12.5 percent; May Duke x Morello, 10 percent; and Royal Duke x Wye Morello, 6.2 percent.

Early Richmond pollen gave good sets of fruit on Brassington and May Duke (Table 6), but not so good as sweet cherry pollen on the Duke varieties (Table 5). Best results, perhaps, will be obtained by using sweet cherries as pollinizers for early blooming and sour cherries for late blooming Dukes.

Duke Varieties as Pollinizers

DUKE CHERRIES AS POLLINIZERS FOR DUKE VARIETIES

Crane (10) found a set of 34.5 percent for Late Duke x May Duke, and 42.8 percent for the reciprocal pollination, but relatively few flowers were used. These crosses were not tried at Wooster. It is shown later, however, that pollen of Late Duke and May Duke gave low percentages of germination, and this would probably be a factor affecting the value of these varieties as pollinizers under orchard conditions.

The sets of fruit obtained when Brassington pollen was used on May Duke and the reciprocal pollination (Table 7) were lower than from sweet or sour varieties as pollinizers for Dukes (Tables 5 and 6).

There seems to be a positive correlation between the ineffectiveness of Duke varieties as pollinizers and their pollen germination.

DUKE CHERRIES AS POLLINIZERS FOR SWEET VARIETIES

In studies of the effect of pollen of Duke cherries on sweet varieties certain investigators show good and others very poor results. Gardner (28) obtained the following sets: Bing x May Duke, 2 percent; Knight x May Duke, no fruit; Lambert x May Duke, 9 percent; Napoleon x May Duke, 2 percent; and Williamette x May Duke, no fruit. Crane (10) for Black Eagle x May Duke, Schuster (59) for Bing x May Duke, and Florin (25) for White Spanish x Empress Eugenie, found sets of 11.5, 27.5, and 11.1 percent, respectively.

TABLE 7.—Duke Cherries as Pollinizers, 1926

		Flowers	Fruit set
		No.	*Pct.*
For Duke varieties			
Brassington	x May Duke	146	8.5
May Duke	x Brassington	141	6.3
For sweet varieties			
Bing	x Brassington	121	8.3
	x May Duke	102	3.0
Napoleon	x Brassington	114	7.0
	x May Duke	96	4.2
Schmidt	x Brassington	133	15.0
	x May Duke	84	2.4
Windsor	x Brassington	109	11.0
	x May Duke	112	4.4
For sour varieties			
Montmorency	x Brassington	183	4.4
	x May Duke	159	2.5

Data secured at Wooster vary from 3 percent to 15 percent and seem to indicate that the Duke cherries tested are rather poor pollinizers for sweet varieties (Table 7). Since sweet varieties are self-incompatible a set of 3 to 15 percent is of some benefit, but it should be borne in mind that an average normal set of 35 percent was obtained for eleven sweet varieties.

DUKE CHERRIES AS POLLINIZERS FOR SOUR VARIETIES

As a rule, when sour varieties are pollinated by Dukes the percentage set of fruit is low. Roberts (54) showed sets of fruit as follows: Early Richmond x Baldwin, 5.4 percent; Early Richmond x Late Duke, 2.2 percent; Montmorency x Baldwin, 1.7 percent; and Montmorency x Late Duke, 3.9 percent. Crane (10) reported sets of 5.1 percent for Kentish x Late Duke, 3.6 percent for Kentish x May Duke, and 9.3 percent for Morello x Late Duke. Best success in the use of a Duke as a pollinizer for a sour variety is reported by Florin (25) who obtained a set of 21.7 percent for Swedish Morello x May Duke.

The data in Table 7 seem to show that Brassington and May Duke are poor pollinizers for Montmorency.

2—SOME FACTORS ASSOCIATED WITH INCOMPATIBILITY

Various causes are responsible for the self- and cross-incompatibility in cherries.

Altho two ovules can be seen in early stages of flower development in the cherry, one of these is suppressed so that only one seed is normally developed. Occasionally, two stigmas are found in a cherry flower, but one is the usual number. On the other hand, in the apple, for instance, there are normally 5 stigmas and 10 ovules per fruit. A considerably higher percentage set of fruit, furthermore, is necessary with the cherry than with the apple for satisfactory commercial yields. The differences in floral structure may be such that, while pollination, pollen potency, tube growth, and fertilization are necessary in each fruit, partial deficiency in these processes may be more serious with the cherry than with the apple.

LITERATURE REVIEW

Potency of pollen.—Most workers on pollination problems test the viability of pollen used. Reports on pollen germination of cherries are given in the literature (23, 24, 25, 28, 40, 49, 57, 59, 67). These seem to indicate that in general the germination of pollen of Duke cherries is lower than that of sweet or sour varieties. Pollen of sweet cherries seems to be more highly viable than that of the two other classes.

Howlett (33), Florin (26), and Kvaale (42) suggested that in the apple there is a positive correlation between the ineffectiveness of varieties as pollinizers and their pollen germination. Many cherry varieties conform to this relationship. A logical explanation for much of the failure of pollen of cherries to germinate properly seems to be that of abnormal chromosome behavior, as outlined later.

Pollen tube growth.—Jost (35) and Correns (9) advanced the hypothesis that when a self-sterile plant is pollinated with its own pollen, the tubes are emitted freely but grow slowly thru the stylar tissues and that special substances inhibit the growth of pollen tubes from pollen of that plant. Osterwalder (51) believed that failure in self-pollination of certain fruit varieties studied by him was due to the inability of the pollen tubes to grow deep enough into the styles. Knight (37) attributed the self-incompatibility of the Rome Beauty apple to slow rate of pollen tube growth in the stylar tissue. Dorsey (18) found that the second drop of plums, which begins two weeks or so after the first drop and extends 17 to 30 days after bloom, is characterized by lack of fertilization. He said that pollination may have taken place, but tube growth was retarded to such an extent that fertilization was prevented, probably by the abscission of the style.

Collins, in conjunction with Crane (12), showed that in both self- and cross-incompatibility combinations the pollen tubes are arrested in the nutrient stylar tissues and fail to reach the ovary, consequently the young fruits fall at an early stage owing to the lack of fertilization. Their observations showed that not only do the ends of the arrested pollen tubes themselves swell up, but in addition a slime sheath forms a semi-permeable membrane around them.

Chittenden (5) claimed there is some evidence that the effectiveness of pollen depends upon the rate of pollen tube growth. He stated that the pollen tube may not elongate sufficiently during the life of the style for fertilization to be effected. This might happen, according to him, with any variety if the weather were so hot and dry as to shorten the life of the style to a marked degree. It seemed likely to him that the growth of the pollen tube was slower in its own style than in that of other varieties. It is known, also, that low temperature retards the rate of pollen-tube growth.

East and Park (19, 20) obtained results which seem to show that the pollen tubes in a selfed pistil are not inhibited in their growth by substances secreted in that pistil, but rather that a substance or substances are secreted in the pistil after a compatible cross which accelerate growth, and that the direct cause of this secretion is a catalyzer which the pollen tube nucleus is able to produce because the zygotic constitution of the plant producing it is different in certain particular hereditary factors from that of the plant on which it is placed.

Prell (53) is said by Sirks (63) to have first proposed an explanation for self- and cross-incompatibility based on an hypothesis of oppositional factors. East and Mangelsdorf (21, 22) stated that in the populations of *Nicotiana* used in their studies the behavior and inheritance of self-sterility and its corollary, cross-sterility, are shown to be determined by allelomorphic sterility factors. The action of these sterility factors is such that the growth of pollen tubes carrying a given factor is inhibited for the most part in the styles of plants carrying that factor.

These citations support the view that factors of various nature are associated with the rate of pollen-tube growth and with the behavior of the contents of the pollen tubes. These factors seem to be concerned at times with the failure of fertilization to take place, and with the dropping of flowers or fruits at a relatively early stage.

Embryo abortion.—Factors of various nature associated with incompatibility and with imperfect seed development are operative after pollen-tube growth has accomplished its purpose and fertilization has been effected.

Miss Bradbury (3) was of the opinion that with Early Richmond and Montmorency, the first drop considered as a whole, or the second drop, cannot be attributed to lack of pollination or of failure of pollen tubes to reach the ovarian cavities. In her investigation, fertilization and a partial development of the embryo had usually taken place in aborting third drop fruits of the sour cherry.

Detjen (16) found in the plum, peach, and apple, that the factor causing embryo abortion appeared to be the chief cause for the dropping of immature fruits. East and Mangelsdorf (21) pointed out that pollen carrying certain allelomorphic factors reaches the ovary and functions in the production of heterozygotes, but is lethal when in the homozygous condition.

Crane (12) believed that the partial failures that occur relatively late, and the formation of fruits with imperfect seeds are probably due to degrees of genetic incompatibility which arrest the embryonic growth at different stages. Continuing, he stated that in the various manifestations of sterility in cherries we have to consider the probability of a varying proportion of defective ovules and also the arrest of embryonic growth due to a lack of balance in the chromosome complement of the developing embryo. Considering the numerous cherries which reach maturity without developing perfect seeds, in many practically only the empty seed coats remain, Crane thought it safe to conclude that if embryonic growth is not arrested until a fairly late stage the fruits, if favorable conditions prevail, are able to remain and reach maturity. He pointed out that there are, however, indications that at this stage the developing fruits are highly susceptible to any adverse influence, and are likely to fall in consequence.

Recent studies by Tukey (69) indicate a relationship between early varieties of cherry groups and failure of seeds to germinate.

Kobel (41) believed that abnormalities comparable to those in pollen development also occur in macrosporogenesis. He was of the opinion that there is a positive correlation in varieties between abnormalities in the pollen and imperfect seed development. That is, he expects a variety showing a low percentage of potent pollen to develop fruits with many abortive seeds.

The references cited indicate that embryo abortion is an important factor in incompatibility as expressed by the dropping of fruits relatively late and in the development of fruits with imperfect seeds.

Chromosome behavior.—Of recent years, investigators have directed attention to abnormal chromosome behavior in horticultural fruits. The chromosomes are regarded as the structures in which inherent character-determining factors reside. Counts of chromosome number or accounts of irregular pollen development are given for the grape by Dorsey (17); for the plum by Dorsey (18) and Crane (12); for the raspberry by Longley (43, 45), Longley and Darrow (46), and Crane (12); for the strawberry by Valleau (70), Longley (44) and, Longley and Darrow (46); for the pear by Osterwalder (51) and Florin (26); for the peach by Knowlton (38), Connors (8), and Asami (1); for the blueberry by Longley (47) and Colville (7); and for the apple by Shoemaker (60, 61), Rybine (55, 56), Kobel (39, 40, 41), Florin (26), Van Eseltine (71), and by others. In most of these fruits polyploidy, or the possession of more than two complete homologous sets of chromosomes, exists. Haploid numbers forming a series of 7, 14, and 21 or of 8, 16, and 32 pairs and of even higher or somewhat intermediate or unbalanced numbers of chromosomes are found in horticultural forms. Multiple numbers generally indicate that more than one species are involved. Crossing between species or forms of a given species is evidently responsible for much of the hybridity or sterility in horticultural varieties.

Darlington (14, 15) and Crane (12) found that in cherries the orthoploid chromosome number of *Prunus avium* (sweets) is 16 and of *Prunus cerasus* (sours) is 32. According to them, the reduction division in the sour cherries by their secondary pairing, shows that *P. cerasus* is a true tetraploid, not derived simply from *P. avium* but differing from this species in possessing additional elements probably derived from *P. fruticosa,* also tetraploid. Of about thirty varieties of domestic cherries examined by them nearly all gave evidence by aneuploidy, or lack of pairing, of hybrid origin. They believed it is therefore possible to consider domestic cherries as resulting from recombinations of different series of eight homologous or partially homologous chromosomes, one in *avium* and two in *cerasus.* The following table from Crane (12) shows the chromosome number (diploid) of the varieties studied. Where irregularities in pairing of chromosomes have been observed in the pollen mother-cell divisions the number of univalents and trivalents is indicated.

TABLE 8.—Chromosomes in Cherries*

Sour Cherries, 32	
Morello	2 univalents
Kentish Red Kentish Red "A" Wye Morello	1 univalent and 1 trivalent
Dukes, 32	
Royal Duke	1 univalent and 1 trivalent
Late Duke Empress Eugenie	2 univalents
Reine Hortense May Duke	6 univalents

Sweet Cherries, 17-19	
Big. Kentish Big. Noir de Schmidt Big. Noir de Guben Noble	17 chromosomes 1 trivalent
Elton Emperor Francis Big. Napoleon Guigne d'Annonay	18 chromosomes 2 trivalents
Waterloo Black Eagle Knight's Early Black	19 chromosomes 3 trivalents

*From Crane (12).

From the morphological point of view it seemed to Crane (12) that the influence of *P. avium* is approximately equal to that of *P. cerasus* in the Dukes and that the part played by *P. cerasus* in the constitution of the sweet cherries and by *P. avium* in that of the sour cherries must be considerable. It is noteworthy that in the selfed families Crane (12) has raised from varieties of *P. cerasus,* seedlings with *P. avium* characters frequently appear; and in families raised from crosses between varieties of *avium* occasional seedlings occur which show *cerasus* characters in a marked degree. Seedlings in families raised from *avium cerasus* crosses show a considerable variety of forms, a few resembling the Dukes in all their characters. These facts, considered in conjunction with the cytological observations and the common occurrence of aborted pollen and defective seeds in varieties usually regarded as pure *avium,* strongly support his view. Moreover, these facts indicate that bi-specific origin is fundamentally involved in the different forms of sterility that Darlington and Crane have met in cherries.

POLLEN GERMINATION TESTS

The results of pollen germination tests conducted in 1927 at the Ohio Experiment Station with 17 cherry varieties are presented in Table 9.

TABLE 9.—Germination of Pollen, 1927

Variety	Agar 1½ percent			
	Temperature 15° C.		Temperature 22° C.	
	Sugar concentration		Sugar concentration	
	10 percent	15 percent	10 percent	15 percent
Abesse	....	20	....	16
Baldwin	....	40	22	24
Bender	....	30	....	26
Brassington	10	11	6	7
Brusseler Braune	....	16	5	7
Dutchess	....	70	85	95
Early Richmond	30	42	70	65
Empress Eugenie	13	18	23	24
Ida	85	87	78	93
Late Duke	7	12	3	3
Louis Philippe	13	25	12	34
May Duke	6	9	3	3
Montmorency	33	35	18	32
Olivet	18	37	....	....
Reine Hortense	....	28	9	4
Royal Duke	1	1	2	2
Sidney	93	90	95	95

A 5 percent cane sugar solution and 2 percent agar were used in addition to the concentrations mentioned in the table, but the germination obtained was so low that presentation of the data seems unnecessary. Counts were made about 18 hours after plating. From 100 to 200 grains were observed for each determination of percentage germination.

Pollen which fails to germinate is useless for fertilization. No variety showed complete failure of pollen germination. Field and laboratory studies indicate a positive correlation between ineffectiveness as pollinizers and pollen germination of a number of varieties. This is particularly evident in some of the Dukes. The fact that Early Richmond gave a higher percentage of pollen germination than Montmorency may be of significance in relation to the higher set obtained from cross-pollination between these two varieties than from self-pollination of Montmorency. Illustrations of the pollen germination of cherry varieties are given in Figure 4.

ABNORMAL CHROMOSOME BEHAVIOR

An explanation of certain factors associated with pollen impotency and hybridity is found by microscopical study of abnormal chromosome behavior in cherries.

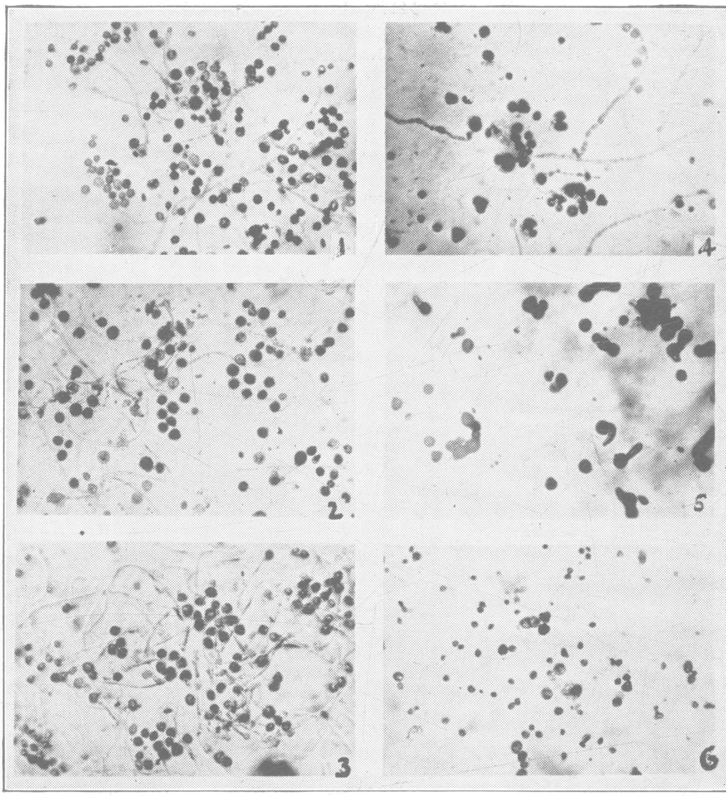

Fig. 4.—Cherry varieties differ in percentages of pollen germination (Table 9). The concentrations of sugar and of agar, and the temperature affect germination. Whenever 5 percent sugar and 2 percent agar were used in the medium very poor germination resulted.

1—Montmorency	15% sugar	1½% agar	Temp. 22° C.
2—Louis Philippe	15% sugar	1½% agar	Temp. 22° C.
3—Sidney	15% sugar	1½% agar	Temp. 22° C.
4—Empress Eugenie	15% sugar	1½% agar	Temp. 22° C.
5—Baldwin	5% sugar	2 % agar	Temp. 22° C.
6—May Duke	10% sugar	2 % agar	Temp. 22° C.

Study of the pollen mother cells indicates that, in general, the basic haploid number of chromosomes is 8 in sweet and 16 in sour and Duke cherries. Variation from these numbers is common in cultivated varieties, due probably to hybrid origin. Chromosome numbers of cherry varieties are shown in Table 8.

Abnormal pollen development was found in every cherry variety studied. Chromosome irregularities were observed most frequently in the Dukes, rather often in sours, and occasionally in sweet varieties. Abnormal chromosome behavior was found most frequently in varieties which gave a low percentage germination of pollen. Sometimes, however, it seemed as if the irregularities observed were not sufficient to prevent germination; but were such that in certain cases pollen tube growth might be adversely affected, and in others that fertilization would not be normal.

The majority of irregularities described in the following sections are illustrated in Figure 5.

Heterotypic and homotypic division.—In the diakinesis period, chromosomes of various sizes and different degrees of fragmentation and pairing were noticed in varieties in which abnormal pollen development occurred. Cleland (6) believed that the probable reason why homologous chromosomes fail to pair in diakinesis in the *Oenotheras* is because they are incompatible, and this incompatibility is presumably due to divergence in their constitution. According to him, relatively heterozygous chromosomes fail to pair, relatively homozygous ones are capable of pairing.

During the heterotypic division, reduction from the diploid to the haploid number occurs in normal development, so that the generative nucleus of the pollen grain inherits only half the number of chromosomes contained in the somatic nucleus. The chromosome number of the daughter nuclei, however, because of different valencies and irregular division, is not always in quantity or quality exactly half of that contained in the mother nucleus. Chromosomes are found which lag and are left on the spindle when the daughter nuclei organize, or are tardy in entering into organization and do not seem to behave normally in the daughter nuclei.

In the interkinesis period, fragments of chromosomes or entire chromosomes distributed almost at random are sometimes observed in the cytoplasm. Some of these are organized as nuclei, but most of them apparently are not. Chromosomes also lag on the spindle during homotypic division and are found in the cytoplasm or organized in nuclei when the tetrad cells are formed.

Supernumerary microspores.—Supernumerary microspores were often found in all Duke and sour varieties studied. This phenomenon was seldom observed in sweet varieties. The abnormal number of microspores was usually one to three more than the usual number of four, but occasionally it was less than four. More than four supernumerary microspores were also observed.

Different explanations of the origin of supernumerary microspores have been offered by investigators. Strasburger (65) and Juel (36) believed that failure of chromosomes to pass to the poles

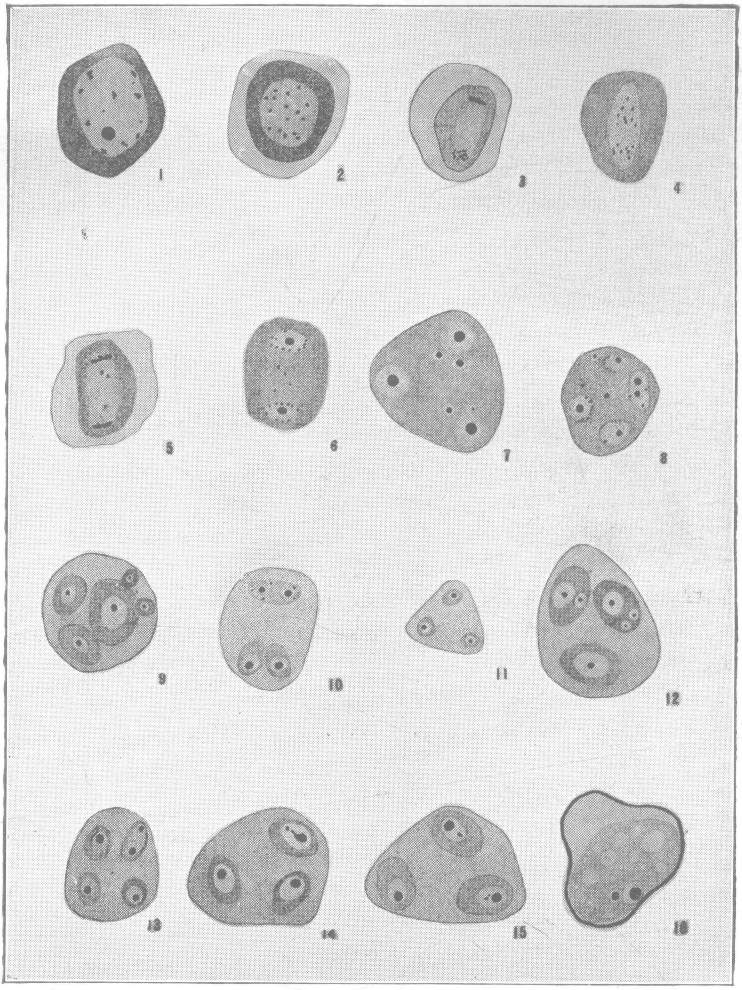

Figure 5

1—Brassington: diakinesis; chromosomes of various sizes and different degrees of pairing and fragmentation.
2—Early Richmond: heterotypic metaphase; 16 pairs of chromosomes. In addition to the paired chromosomes, univalents and trivalents also occur in this variety.
3—Early Richmond: heterotypic late anaphase; 16 pairs of chromosomes.
4—Windsor: heterotypic anaphase; 8 pairs of chromosomes. Additional chromosomes and univalents and trivalents also occur.
5—Empress Eugenie: heterotypic telophase; lagging chromosomes.
6—Empress Eugenie: chromosomes left on the spindle after the daughter nuclei walls have been formed.
7—Royal Duke: homotypic telophase; nuclei in cytoplasm.
8—Empress Eugenie: young tetrad microspores; chromosomes and small nuclei in the cytoplasm; arrangement of chromatin in the microspore nuclei.
9—Reine Hortense: polyspory.
10—Lambert: one cell has not divided; distribution of chromatin.
11—Montmorency: a small tetrad cell.
12—Bing: polycary.
13-15—Lambert: distinct separation of chromatin in nuclei of the microspores.
16—Dyehouse: vacuolation.

at the first division gave rise to small microspores. Fullmer (27), however, was of the opinion that supernumerary microspores resulted from the division of one or more members of the tetrad. Fewer than the usual number of microspores may result, as Goulden (29) found in oat dwarfs, from failure of the homotypic division to take place.

As a rule, the supernumerary microspores are considerably smaller than normal ones, and upon liberation appear as small pollen grains. Sometimes, however, larger than normal microspores are evident. It is assumed in cherries that abnormal microspore number is associated with irregular division, and that very small pollen grains possess fewer than the normal number of chromosomes.

Additional nuclei in the microspore.—Polycary, or the presence of additional nuclei in the microspore, was rather frequently observed in cherries. This is considered to be an indication of abnormal pollen development. The small size of some of the additional nuclei seems to indicate the presence in them of unpaired or of diminutive chromosomes.

Separation of chromation in the nucleus of the microspore.—Certain cherries, particularly sweet varieties, seem to be characterized by a separation of the chromatin in the nucleus of the microspore. While it is possible that this is simply another stage of polycary, it seems to be a distinct abnormality.

SUMMARY

1. In a normal year all sweet cherries grown at Wooster usually overlapped sufficiently in bloom for cross-pollination. Standard sour varieties generally bloomed too late to be satisfactory pollinizers for sweet cherries. Duke cherries, for the most part, bloomed between sweet and sour varieties.

2. It was exceptional for sweet varieties and many Dukes to set fruit when selfed. Most sour varieties set reasonably good crops when selfed.

3. Bing, Lambert, and Napoleon were cross-incompatible, but pollinated other varieties successfully.

4. Except for certain cross-incompatible combinations, sweet varieties as a rule were good pollinizers for one another. Windsor gave the highest sets, but other varieties also gave good sets.

5. Sweet cherries fertilized sours when hand pollinated, but the two usually did not bloom together.

6. Dyehouse and English Morello set a fair percentage of fruit on Early Richmond and Montmorency, but no increase in set over that of self-pollination was obtained. Pollination of Montmorency by Early Richmond seemed to increase the set of fruit over that of self-pollination.

7. Sour cherries did not seem to be good pollinizers for sweet varieties because the two species did not bloom simultaneously. The percentage set of fruit was low.

8. For early blooming Dukes, sweet cherries are suggested as pollinizers. For late blooming Dukes, sour cherries seem to be the most suitable.

9. The sets of fruit obtained when Brassington pollen fertilized May Duke, and the reciprocal pollination, were lower than where sweet or sour varieties were used as pollinizers for Dukes. There seemed to be a positive correlation between the ineffectiveness of Dukes as pollinizers and their pollen germination.

10. The Dukes tested did not seem to be very good pollinizers for sweet varieties or for Montmorency.

11. Various causes are responsible for the self- and cross-incompatibility in cherries. Potency of pollen, pollen tube growth, embryo abortion, and chromosome behavior are factors associated with incompatibility.

12. Some of the Dukes gave very low percentages of pollen germination. The highest germination obtained for Montmorency was 35 percent, whereas that for Early Richmond was 70 percent. Ida, a sweet variety, showed 93 percent viable pollen, and Dutchess and Sidney 95 percent. A logical explanation for much of the failure of pollen of cherries to germinate properly seems to be that of abnormal chromosome behavior. Varieties differed in pollen viability.

13. Factors of various nature seem to be associated with the rate of pollen tube growth and with the behavior of the contents of the pollen tubes. These factors seem to be concerned at times with the failure of fertilization to take place and with the dropping of fruits at a relatively early stage.

14. Embryo abortion seems to be an important factor in incompatibility as expressed by the dropping of fruits relatively late and in the development of fruits with imperfect seeds.

15. The chromosomes are regarded as the structures in which inherent character-determining factors reside. A study of the

pollen mother cells indicated that, in general, the basic number of chromosomes is 8 in sweet and 16 in sour and Duke cherries. Variation from these numbers is common in cultivated varieties, due probably to hybrid origin. Univalents and trivalents often are found in addition to the bivalents.

16. Abnormal pollen development was found in every cherry variety studied. Chromosome irregularities were observed most frequently in the Dukes, rather often in sours, and occasionally in sweet varieties. Abnormalities in pollen development are evidenced microscopically by the various sizes and different degrees of fragmentation and pairing of the chromosomes in the diakinesis stage, by the lagging and irregular behavior of the chromosomes in division, by the presence of supernumerary microspores, by additional nuclei in the microspore, and by separation of chromatin in the nucleus of the microspore.

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